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jusqu'ici je ne connaisse pas d'observations coincident avec mon dessin de $6^h\ 35^m$; je suis persuadé que l'on y verrait la bande que j'ai représentée.

"A défaut de coincidence parfaite, je m'appuierai sur vos dessins 15 et 18, qui renferment des traces évidentes de bandes courbées, précédant celle dont vous vous occupez, car la longitude est ici 200°·1 et 220°·6.

"Ces prolongements établissent une communication entre le bord S de la bande équatoriale et des régions plus septentrionales, semblant avoir été très fréquentes en 1873; on en trouve un autre exemple dans les crochets de mes dessins 2, 9 et 11, que j'avais jugés visibles à peu près sur le même hémisphère, et qui, d'après vous, seraient complètement distincts."

June 8, 1874.

Observations of Jupiter, 1874. By E. B. Knobel, Esq.

Observations of *Jupiter* were commenced on February 8th, 1874, and up to the present time but few opportunities of fair observation have been lost. On the whole the opposition this year has been a very favourable one for study of the planet; a large number of fine nights, coupled with good definition, enables one, I think, to submit one's results with some amount of confidence.

The series of 35 drawings, which I beg to present to the Society, has been made with an 8½-inch silvered glass reflector by Browning, of excellent quality. The powers used were Browning-achromatic eye-pieces of 144, 208, and 250. Every care was exercised to represent what was actually seen, and to give the relative intensity of the various features; and with a view to obtain as impartial evidence as possible, no comparison of the drawings was made till they were all (with two exceptions) copied out in their present form.

The changes in the planet's aspect since the last opposition have been so numerous, that I have included in the series nearly all the drawings I was able to make. It might be thought that in such a series of drawings, many of which represent the same zeuographical meridians, some would be merely replicas of others, but I have found that this is not the case. The state of the atmosphere has made definition variable, and, coupled with absolute changes in the features of the belts, renders it almost impossible for two drawings of *Jupiter* having the same longitude, but executed at different periods, to correspond exactly. Some of the principal features seem to have been permanent for the whole period of observation; others it is difficult to reconcile with what was observed on the same meridian at a subsequent date.

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I have arranged the drawings in order of date, but to facilitate comparison, they are given in the following table in order of rotation, the longitude of the centre of the disk being calculated from the tables published in the *Astronomical Register.**

To eliminate as much as possible discrepancies which may be due only to imperfect definition, I append a column in which the number of crosses indicates *very roughly* the state of the atmosphere, in a scale of 4 degrees, as recommended by Dr. Lohse in his circular of last year:—

X = Definition. Very good, very sharp and steady.
XX = " Good and steady, but not continuously so.
XXX = " Tremulous; only momentary good views.
XXXX = " Bad, not sharp, though principal features discernible.

No. of Sketch	Date	h	m		Longitude	Definition
20	April 5	8	20	G.M.T.	3	X
17	March 26	10	25	"	12	XX
31	April 29	8	40	"	31	X
6	March 7	10	45	"	41	XX
18	March 31	10	40	"	54	XX
13	March 24	10	15	"	64	XXX
7	March 7	11	25	"	65	XX
34	May 16	8	45	"	74	X
24	April 12	11	0	"	75	XXXX
21	April 5	10	40	"	88	XX
14	March 24	11	0	"	92	XX
25	April 20	8	13	"	99	XX
22	April 8	8	40	"	107	X
8	March 7	13	40	"	147	X
15	March 25	8	30	"	152	XX
23	April 8	10	10	"	162	XX
32	May 2	10	33	"	190	XX
16	March 25	10	0	"	206	X
5	March 6	10	15	"	232	XX
11	March 18	10	25	"	246	X

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* It would seem that there is either some error in the rotation period of *Jupiter*, assumed by Mr. Marth in these tables, or else considerable proper motion in the features of the planet. Sketches Nos. 20 and 35 correspond as far as the large white marking in the Equatoreal zone is concerned; but the longitude of the centre of No. 20 is 3°·0, and that of No. 35 is 330°·0, showing an apparent error of nearly 1 hour in time, whereas I have every reason to believe there is no serious error in the time of any of the drawings.

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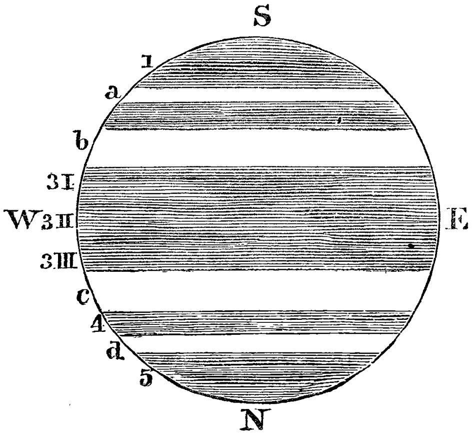
No. of Sketch.	Date.	h	m		Longitude.	Definition.
4	March 1	11	45	G.M.T.	253	XX
26	April 21	8	30	,,	260	XX
2	February 17	12	30	,,	272	X
28	April 23	10	30	,,	274	XX
12	March 23	10	30	,,	283	XX
29	April 23	11	0	,,	292	X
10	March 11	11	10	,,	299	X
3	February 17	13	45	,,	317	X
30	April 28	11	0	,,	325	X
27	April 21	10	18	,,	326	XX
33	May 8	9	17	,,	329	X
35	June 1	8	57	,,	330	XX
19	April 5	7	25	,,	330	X
1	February 8	12	20	,,	349	X
9	March 9	11	0	,,	351	XXX

For the purpose of comparison with the series of chromolithographs of *Jupiter* given by Lord Rosse in the *Monthly Notices* for March, I beg to make use of his diagrams of the belts, in which the dark bands are designated by figures, and the light spaces by letters.



Zone 5. The North Polar zone has appeared about as dark as last year, and in 28 of the sketches it is shown separated from the North Temperate belt 4. In the others no division can be detected between 4 and 5. In seven of the sketches a narrow belt darker than 5 is shown lying between it and 4. This feature was not observed at all last year. On some nights this narrow belt was seen merely as a thin dark edge to the Polar zone, and it was along this that Satellite III. transitted on March 25.

Zone d has appeared much narrower than last year, and, as mentioned above, on many nights could not be perceived at all.

Zone 4. The North Temperate belt, which has been so conspicuous for the last few years, has appeared on some nights exceedingly faint, and on others singularly darker and more distinct. It has been said to have entirely disappeared this year, but on every occasion my drawings show its existence. Sometimes no separation could be detected between it and 5, but on

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those nights it was clearly marked as a broad darker edge to that zone. In sketches 2, 3, 29, and 33 the north edge of this belt is shown decidedly darker than the rest, as observed last year.—*Monthly Notices*, June 1873.

Zone c. The only feature noticed in this, the brightest zone of the planet, was a small projection from the Equatoreal zone, shown in sketches 12, 22, and 27.

Zone 3. The Equatoreal zone has exhibited many curious changes since the last opposition. The northern portion, 3 III., shows in some drawings a narrow horizontal bright band extending all across the disk; in others there are great breaks and gaps, which sometimes appeared to have no line separating them from c, but these gaps were always observed to be less bright than the adjacent zone. A curious dark spot was noticed on the north edge of 3 III. on April 23rd.

The Equator, 3 II., was on all occasions observed to be marked by a bright band, which contains some very curious bright spaces, referred to hereafter.

The South Tropical belt, 3 I., has appeared invariably darker than 3 III. This portion of the Equatoreal zone contains a bright horizontal division, which has not been noticed to be continuous all round the planet; only one sketch between longitudes 70° and 190° gives any indication of its existence between those meridians. In some drawings the northern edge of 3 I. is marked by a much darker line. A curious thinning out of this belt towards the east is observed about longitude 320°. Between longitude 64° and 152° this belt bulges out and widens towards the south by reason of a slant streak from 2, which apparently extends itself along the south edge of § I., and so widens it, but the extra width appeared rather fainter than the rest of 3 I.

Zones 2 and b. The region occupied by these two zones has displayed more evidence than any other of change since last year. In long. 330° a curious curved projection from 2 stretches downwards across b to the Equatoreal zone; this has been a permanent feature during the whole period of observation. East and west of this curved projection 2 seems entirely broken up into white cloudy patches and breaks in the continuity of the belt. These white patches have not been noticed between longitudes 40° and 160°. About longitude 40° this South Temperate belt 2 begins to send out to the north-east a slant streak, which continues until it joins the Equatoreal zone in longitude 70°. In some drawings of the planet between longitudes 100° and 270° a narrow dark belt is shown running along the centre of b.

Zone a. This bright band has very rarely been seen sharply defined, though it has been detected on most nights of observation. In sketch 31 a narrow dark streak is shown running along the centre of this zone.

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Zone 1. The South Polar zone has always appeared fainter than the North.

The colours of *Jupiter* this year have been far more conspicuous than in 1873. A marked change in the tint of the Equatoreal zone has taken place. In May 1873 it was observed of a decided brick red tint; on no occasion this year has that tint been remarked, but a bronze yellow or sienna (mixture of raw and burnt sienna) has prevailed for the whole period of observation, though perhaps on one or two nights the tint approached more of a rich yellow.

The bright band c, immediately north of the Equatoreal zone, has appeared always blue, whether from contrast with the adjacent region or not I cannot say, as what observations I could make with the Equatoreal zone concealed by a bar were unsatisfactory.

One of the most noticeable features in the colours of *Jupiter* is the difference in tint of the North and South Polar zones, already recorded and depicted by Lord Rosse in the interesting series of chromolithographs published in the *Monthly Notices* for March 1874. The South Polar zone has seemed to partake of the tint of the Equatoreal zone in a fainter degree; while the North is, as it has appeared for the last few years, of a bluish grey.

In Mr. Browning's beautiful coloured drawing of *Jupiter*, published in *The Student* for 1869, the dark southern band of the Equatoreal zone is depicted and described as "madder-brown." This particular tint I observed in the same portion of the Equatoreal zone (the South Tropical belt) on several occasions, noticeably on March 31st, at 10.40, when the colours were compared with Mr. Browning's drawing.

I should add that distinct colour views of *Jupiter* seem to go hand in hand with sharp definition, and when the air has been unsteady, colours have been imperfectly seen. With regard to the power necessary to show colour, I must say that a Browning-achromatic eyepiece of 144 has revealed them to me as distinctly and decidedly as any higher power.

The darkest portion of the disk is undoubtedly the South Tropical belt, but this is not uniform in tint, as mentioned above.

The brightest spaces were observed on the Equator in the central light band of the Equatoreal zone. These it has been impossible to represent in the sketches. Particular bright (almost brilliant*) narrow streaks were observed adjacent to the dark South Tropical belt, 3 III. Nothing exactly corresponding is noticed in Lord Rosse's drawings, but somewhat similar light spaces are depicted by Mr. Browning in his drawing before referred to.

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* Tacchini describes the appearance in 1873 of certain bright streaks on the Equator of *Jupiter*, as " très vives, comme argentées."

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An excellent observation of Mr. Lassell's bright spots on the Southern belts was made on May 17th, at 10.0. I was examining the planet with 144, and made a sketch of it, definition being good. Thinking to improve definition, I put on a 6½-inch stop, and immediately perceived a brilliant spot like a minute satellite on the south edge of the Equatoreal zone, in zone b. I should say it appeared more brilliant than a satellite, and smaller. Further search enabled me to make out two more spots on the same belt. It is said that these spots are seen only with large apertures; but I have no doubt that reducing the aperture from 8½ inches to 6½ inches first revealed them to me, by materially reducing the brightness of the planet's disk, while these minute spots were brought out in greater contrast; hence they must be of considerable intrinsic brightness. On this evening, with the full aperture, the belts were seen more minutely than with the 6½-inch stop on, but the bright spots were not nearly so distinct as with the reduced aperture. This fact I satisfied myself about without doubt.

The shadows of the satellites on the disk have been inserted in the drawings as near as possible in the positions observed with regard to the belts. On March 25th the transits of II. and III. with their shadows were observed. At 8.30 III. appeared as a small dusky spot, not round but elongated E. and W., which traversed the edge of the North Polar zone, and a little north of its shadow, which made the transit along the centre of the bright division d. II. and its shadow transitted the North Temperate belt. At 10 o'clock, some minutes before the satellites had begun to protrude beyond the edge of the disk, they were both very distinctly visible as white spots, though when II. was near the centre I could see it only with the greatest difficulty. Precisely the same phenomenon was observed on April 26th, when II. was in transit, and on May 2nd, when Satellite I. was on the disk. On both occasions the satellites were nearly invisible in mid-transit, and on nearing the edge they started into distinct visibility.

The greater distinctness of the satellites themselves when near the limb is a curious phenomenon which has been repeatedly observed by astronomers, but which seems to require explanation. On the occasions mentioned above II. transitted a dark belt, which was most dark near the centre, and fainter towards the limb, yet the satellite was almost invisible when on the darkest part of the belt, and was bright and distinct when the background of the belt was faintest. Satellite III. on March 25th, 1874, appeared as a dark spot when in mid-transit, and on nearing the edge appeared as a bright spot without trace of duskiness. But on March 26th, 1873, Satellite IV. made the whole transit as a dark spot, and was not perceptibly less dark at egress than in mid-transit.

Cloudy weather has prevented any observation of IV. in transit this year. On May 2nd, at 6.40, when this satellite was

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on the disk, the planet was picked up in daylight, and though all the belts could be discerned, I could detect nothing of the satellite.

Since writing the above, I have read Mr. Brett's paper on *Jupiter*, in the last number of the *Monthly Notices*, which states that he has detected a dark border upon the white patches on the Equatoreal zone; and this border being always situated on the side furthest from the Sun, he therefore argues that these white patches must be high above the body of the planet and cast shadows.

The feature to which Mr. Brett directs attention is a very curious one, which I do not think has altogether escaped my notice; though as no time is mentioned when this phenomenon was observed by him, I do not know to which particular spots he refers. In the accompanying drawings I have endeavoured to represent similar appearances, if not identically the same; but if so, it is difficult to make them accordant with Mr. Brett's theory.

Jupiter was in opposition to the Sun on March 17th. In sketch No. 14, made on March 24th, at eleven hours, a large white patch or break will be noticed in the northern portion of the Equatoreal zone. The east boundary of this patch was observed much darker than the west, and this darker portion extended for about 5° or 6° of Longitude. Again, in sketch No. 18, made on March 31st, at 10.40, only fourteen days after opposition, the same white patch is shown; and as the dark border east of it was carefully observed that night, I endeavoured to delineate, as accurately as I could, its apparent length (east and west), which I find to be about 8° or 10° of Longitude. Now, it would be easy to calculate what the height of the white patch should be to cast a shadow that length, only fourteen days after opposition. This particular white patch has been observed up to May 16th, and is depicted in two sketches made that evening. In these drawings the dark following space certainly gives a *primâ facie* support to the theory of shadows; but inasmuch as this dark space was observed no longer (east and west) on this evening—two months after opposition—than on March 31st, I must think a true solution of the appearance has hardly been found.

I should add that some of the white patches were not noticed to have any dark border, whilst others, such as those represented in sketches 17, 22 and 30, had dark boundaries on both sides.

Stapenhill, Burton-on-Trent,
1874, *June* 9.